The X Converter

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+V_{IN} \quad L_1 \quad (1:1) \quad L_2 \quad (1:1) \quad +V_{OUT}
The X Converter
(Yet another new SMPS topology)

- Non isolated, single switch, *non inverting* buck-boost output.
- Based on the cross connecting of two independent split inductors.
- Continuous current on both input and output (ripple steering).
- Second order control-to-output response (with proper damping).
The X Converter

What it is …

• A little known buck-boost topology that provides a non inverting (non isolated) output using only a single switch;
• A topology that inherently provides continuous current on both input and output (about the same percentages as an equivalently size buck converter with an input filter);
• The optimum choice in certain, limited situations.

What it is not …

• A Power Conversion Panacea (long live the basic buck and sliced bread);
• A zero ripple topology (these are like perpetual motion machines – they simply do not exist);
• The most appropriate topology for most power conversion applications.
The X Converter – History

• First discovered in the mid 1980s while analyzing the controversial (albeit highly entertaining) claims of Dr. Ćuk[1] with regard to the universal superiority of his family of converter topologies.

• The X Converter was actually born from a true understanding of the workings of the double ripple “cancelled”, coupled core Ćuk converter (aka the Integrated Magnetics Ćuk converter).

• When presented with a schematic of the X Converter, Dr. Ćuk stated that, although very intriguing, it was completely new to him.
Deriving the X Converter

Integrated Magnetics Ćuk Converter
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Driving the X Converter

Bucking the common mode voltage with added drive windings

Bifilar gate drive

Driver IC with signal and power grounds
Driving the X Converter

Note: these grounds must not be connected but they may be swapped for easiest signal viewing.
X Converter Line Step Response
X Converter Inductor Ripple

[Image of a graph showing the current waveforms for I(L3), I(L4), I(L5), and I(L6) over time.]
X Converter Duty Cycle to Output Transfer Function

The X-Converter
(small signal analysis - plot $V(o)$ and note how phase flips)

.ao dec 301 100 300k
.param $V$=15 $m$=3 $n$=1
.step param $V$ list 10 15 20
.step param $m$ list 1 2 4 8

$V_2$ [12k]
$R_{ser}$=10m

$V_3$ [100µm]

$V_1$ [1µm]

$B_1$ [1µm]

$B_2$ [1µm]

$L_1$ [102µm]

$L_2$ [12k]

$L_3$ [102µm]

$L_4$ [100µm]

$C_1$ [3.3µm]

$C_2$ [3.3µm]

$C_3$ [3.3µm]

$C_4$ [3.3µm]

$C_5$ [33µ]

$I$ = $V(D)/([L_1]+[L_3])$

$V$ = $V(D)/([1,4]+[3,2])$
X Converter Duty Cycle to Output Transfer Function

Note: double zero moves from right to left half plane.
Response without Damping
Thank You!